[redacted]

FRANKFORD ARSENAL

REPORT NO. R-1275

ORDNANCE CORPS U.S.A.

PENETRATION PERFORMANCE OF 30 mm SOLID NOSE HE SHELL

PART I

BY

J. R. Kymer and H. E. Fatzinger

PROJECT TS1-48

PITMAN-DUNN LABORATORIES
FRANKFORD ARSENAL
PHILADELPHIA, PA.
August 1955

Copy No. 45

[redacted]

UNCLASSIFIED

AD 64 651

CLASSIFICATION CHANGED
TO: UNCLASSIFIED
FROM: CONFIDENTIAL
AUTHORITY:
ARRADCOM 1tr
19 NOV 79

UNCLASSIFIED

```
-- 1 -  AD NUMBER: 064651
-- 2 -  FIELDS AND GROUPS: 19/1
-- 3 -  ENTRY CLASSIFICATION:   UNCLASSIFIED
-- 5 -  CORPORATE AUTHOR: FRANKFORD ARSENAL  PHILADELPHIA PA PITMAN-DUNN
--      RESEARCH LABS
-- 6 -  UNCLASSIFIED TITLE:     PENETRATION PERFORMANCE OF 30 MM SOLID NOSE
--      HE SHELL. PART I
-- 8 -  TITLE CLASSIFICATION:   UNCLASSIFIED
--10 -  PERSONAL AUTHORS: KYMER, J.R.; FATZINGER, H.E.
--11 -  REPORT DATE:      AUG   , 1955
--12 -  PAGINATION:     27P   MEDIA COST:  $  6.00 PRICE CODE:   AA
--14 -  REPORT NUMBER:    R-1275
--20 -  REPORT CLASSIFICATION:  UNCLASSIFIED
--23 -  DESCRIPTORS:      *HIGH EXPLOSIVE AMMUNITION, PENETRATION,
--      PROJECTILES.
--24 -  DESCRIPTOR CLASSIFICATION:    UNCLASSIFIED
--25 -  IDENTIFIERS:      30-MM ORDNANCE ITEMS.
--26 -  IDENTIFIER CLASSIFICATION:    UNCLASSIFIED
--33 -  LIMITATION CODES:  1
--35 -  SOURCE CODE:      283750
--36 -  ITEM LOCATION:    DTIC/NTIS
--         <<P FOR NEXT PAGE>> OR <<ENTER NEXT COMMAND>>
y                                          *MSG RECEIVED*
1a ROW=24 COL= 01        <Ctrl>H For Help                    N  Poll
```

Initial distribution has been made of this report in accordance with the distribution list contained herein. Additional distribution without recourse to the Office, Chief of Ordnance, may be made to United States military organizations, and to such of their contractors as are certified to be cleared to receive this report and to need it in the furtherance of a military contract.

REGRADED Unclassified
DA Form 1575

BY AUTHORITY OF dtd. 22 NOV 66
Frankford Arsenal

ON 25 Sep 67

REPORT R-1275

PENETRATION PERFORMANCE OF 30 mm SOLID NOSE HE SHELL

PART I

Project TS1-48

Prepared by

J.R. KYMER
Physicist

H.E. FATZINGER
Chief
Penetration Mechanics Branch

Reviewed by

G.C. WHITE, Jr
Chief,
Physics and Mathematics
Division

H.W. EUKER
Research Advisor
Physics Research Laboratory

Approved by

W.J. KROEGER
Director
Physics Research Laboratory

C.C. FAWCETT
Director
Pitman-Dunn Laboratories Group

For

JOSEPH M. COLBY
Brigadier General, USA
Commanding

ACKNOWLEDGMENT

The authors wish to thank Mr. Sidney Ross and Mr. Stephen Kucsan of the Ballistics Division of the Pitman-Dunn Laboratories for their cooperation and guidance in the interior ballistics and original design phases of this work.

TABLE OF CONTENTS

OBJECT

To develop a 30 mm thin-walled, base fuzed, HEI shell which has optimum target penetration characteristics.

SUMMARY

A solid nose, based fuzed 30 mm shell has been designed which is at least twice as effective for penetration as the present nose fuzed design (T306) against 60° and 70° obliquity aluminum armor targets, and which practically satisfies the ultimate penetration requirements. It is possible for this shell to remain intact after defeating 3/4 inch 24S-T4 aluminum alloy plate between 45° and 70° obliquities, and 5/8 inch plate from 0° to 75° obliquities at velocities of 2800 to 3000 fps. This shell, however, only partially meets the requirements of weight, explosive capacity, and exterior contour. Modifications of the present inert loaded design are being made to fulfill the specified requirements.

It is recommended that the blunt nosed principle of design be considered for other types of HE and small arms armor piercing ammunition.

AUTHORIZATION

OCM C663, FA 47/1952, OO 471./91/8 (S)

Minutes of Sixth Aircraft Ammunition Conference at Aberdeen Proving Ground, 5 and 6 May 1953, OO, ORDTS

INTRODUCTION

It has been found[1] that, in order to obtain effective blast damage on aircraft structures with HEI ammunition, the projectile must remain intact after penetration of the surface so that high order detonation of the explosive occurs inside the aircraft structure. The present interim 30 mm HEI shell (T306E10) (Figure 1) under development for Air Force use remains intact after defeating up to 1/4 inch 24S-T4 aluminum alloy plate at 60° obliquity. The original Air Force requirement was the defeat of targets up to 5/8 inch plate at 80° obliquity. However, the urgency of procurement of combat rounds for early use necessitated the acceptance of reduced "interim" performance. On a reduced priority basis, studies were conducted in an attempt to provide the higher level of performance.

This is a partial report on a program undertaken to develop a shell capable of the higher level of performance, which will have the following characteristics:

Projectile weight (with fuze)	3900 gr max
HE filler weight	750 gr (Δ = 2.0 gm/cc)
Muzzle velocity	2800 to 3000 fps
Exterior contour	Match T306 HEI projectile
Chamber pressure	40,000 psi (Cu) max, avg

It was believed that the higher performance could be obtained if the front of the shell were solid and if a suitable base fuze were provided. Therefore, a project was undertaken to develop a base fuzed shell.

From penetration studies[2,3] performed with 20 mm armor piercing solid steel projectiles, it is known that a flat or blunt nosed projectile can bite in and defeat high obliquity thin steel targets at much lower velocities than conventional nosed projectiles. Also, against high obliquity targets, flat nosed projectiles can remain intact at higher velocities than conventional projectiles.

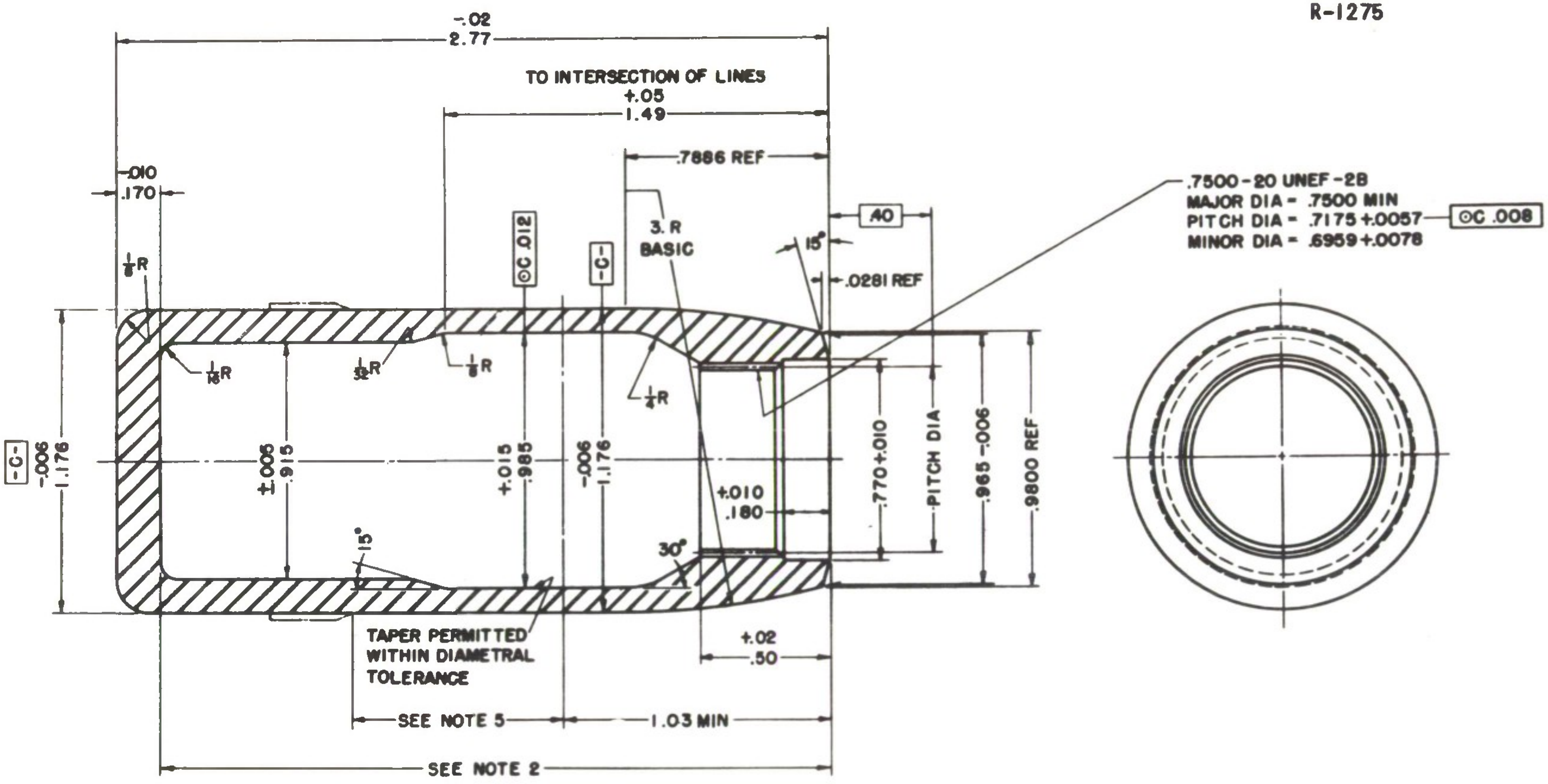
---

1. J. N. Sermoussakis, "Report on Tests of the Effect of Blast from Bare and Cased Charges on Aircraft," Aberdeen Proving Ground BRL Memo Report 436, 1 July 1946.

2. H. W. Euker and C. W. Curtis, "Design of Armor Piercing Projectiles for High Angle Attack," Frankford Arsenal Report R-1070, June 1952.

3. J. R. Kymer and H. E. Fetzinger, "Solid Steel AP Projectiles - Conventional, Truncated, and Tipped Truncated Ogival Types," Frankford Arsenal Report R-1166, October 1953.

Neg. #26240-1
R-1275



BODY FD18083A
STEEL-SPEC MIL-S-43
FINISH 125

Figure 1. Interim 30 mm HEI shell

MATERIALS AND METHODS

Composition and Heat Treatment

The shell used were made of SAE 1137 and SAE 1045 steels. The shell of SAE 1137 steel were austenitized at 1550° F, quenched in oil, and then tempered at 250°, 400°, 600°, and 800° F.

Model 1 shell of SAE 1045 steel were austenitized at 1650° F, quenched in oil, and then tempered at 250° F (R_c 42), 400° F (R_c 38), 600° F (R_c 34), and 800° F (R_c 30). Model 2, 3, and 4 shell of SAE 1045 steel were austenitized at 1550° F, quenched in brine, and tempered at 300° F, (R_c 56), 375° F (R_c 52), 450° F (R_c 47), and 500° F (R_c 42). Steels and hardnesses for the different designs are listed in Table I.

Table I. Material and Hardness of Steel Tested

Model	Steel	Approximate Hardness (R_c)
1A	1137	42, 38, 30, 27
1B	1045	42, 38, 34, 30
2A	1137	42
2B	1045	47, 42
3A	1137	42
3B	1045	47
4	1045	56, 52, 47, 42

All shell were inert loaded with IM 110 inert mix, which simulates the explosive filler to be used, and had aluminum base plugs (Figure 2) in lieu of the base fuzes being developed for this shell. Weights of the various components, with the shell capacities, are listed in Table II.

Table II. Weights of Components and Shell Capacities

Model	Weight of Body g ~~(gm)~~	Weight of Base Plug g ~~(gm)~~	Weight of Inert Filler g ~~(gm)~~	Total Weight g ~~(gm)~~	Capacity (cc)
1	2150	310	700	3160	22.8
2	2790	310	785	3885	22.8
3	2850	310	785	3945	22.8
4	2940	445	655	4040	19.4

Neg. #26240-2
R-1275

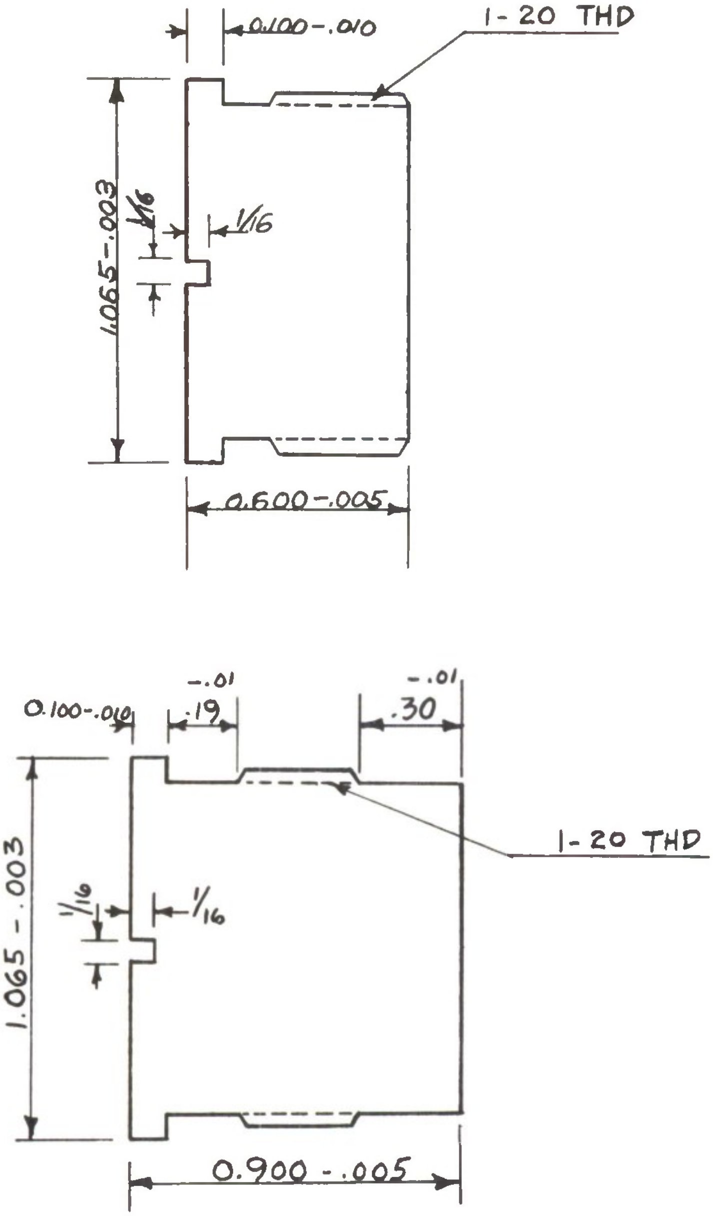


Figure 2. Aluminum Base plugs
Upper - Models 1, 2, 3
Lower - Model 4

Rotating Bands

All of the thin walled shell described in this report had welded copper overlay bands. Had these shell had regular band seats, they could not have withstood the swaging forces necessary to seat conventional bands. Even if banding had been achieved by providing internal support, the shell would have collapsed upon firing. Because of the failure of thin walled shell with conventional rotating bands, a new type of rotating band was conceived and developed by Pitman-Dunn Laboratories Group of Frankford Arsenal. The new bands, called "welded overlay rotating bands," are applied directly on the full diameter base section of the shell, thus eliminating the band seat. The overlay band is applied before heat treating. The heat treatment serves as an anneal which is necessary both for machining purposes and for proper functioning as a rotating band.

The bands are machined from welded overlays deposited circumferentially on the projectile by the inert-gas-shielded metal-arc welding process. This process employs a bare wire electrode which is continuously fed and consumed. This adaptation of conventional welding has favorably approached the advanced states of controlled procedures and ballistic studies, not only on this shell, but also on projectiles in sizes ranging from caliber .50 to 280 mm.

Some of the advantages of the welded overlay band are:

(1) The band becomes an integral part of the projectile because of the fusion bond, thus eliminating the possibility of the band becoming loose or separating from the projectile during its flight.

(2) No band seat is required. This permits the use of thin walled shell with increased explosive capacity.

(3) The occurrence of quench cracks is reduced.

(4) Favorable and uniform ballistic performance is obtained.

Plate

All firings were conducted against various thicknesses of commercial 24S-T4 aluminum plate at obliquities of 0, 30, 45, 55, 60, 65, 70, and 80 degrees. The plates were held rigidly in a mount (Figure 3) designed specially to enable high-speed radiographs to be taken of the projectiles either before, during, or after penetration, and to permit accurate adjustment of the angle of obliquity.

Firing

All rounds were fired from a 30 mm Mann type barrel. Velocities were measured over a ten-foot base line by a counter chronograph actuated by breaking printed circuits.

Evaluation Using High-speed X-rays

High-speed X-ray pictures were taken of all rounds after they had penetrated the plate. From examination of the X-ray negative, it is possible to determine whether or not the shell remained intact without the delay and the work necessary in recovering high velocity projectiles in some medium that should not produce any additional deformation or rupture. Furthermore, the extent and location of deformation can be noted and, by proper selection of targets, the region of initiation of failure can be determined. After these observations have been made over a range of obliquities, it is possible to make design modifications which will increase the shell effectiveness.

The X-rays were taken with a unit originally designed by Westinghouse Electric Co. in conjunction with this arsenal, for use in terminal ballistic studies. The unit consists of a control unit, high voltage rectifier unit, surge generator, and an X-ray tube (Figure 4).

A Micronex interval timer is used in conjunction with the high-speed X-ray unit to insert, electronically, a preselected time interval between the initiation of the timing cycle and triggering of the surge generator. The projectile breaks a printed circuit, which initiates the timing cycle. After a selected time, the surge generator is discharged, giving an impulse of up to 360,000 volts to the X-ray tube. For the radiographs shown in this report, an impulse of 300,000 volts was used. The X-ray tube was placed five feet from the line of flight of the shell, and the cassette three inches from the line of flight.

RESULTS AND DISCUSSION

Model I

A sketch of the first design is shown in Figure 5. A double conical nose shape was chosen from experimental results obtained with solid 20 mm AP projectiles against homogeneous steel targets.[3] It was observed that, against high obliquity targets,

---

3. Ibid

Neg. #26240-3
R-1275

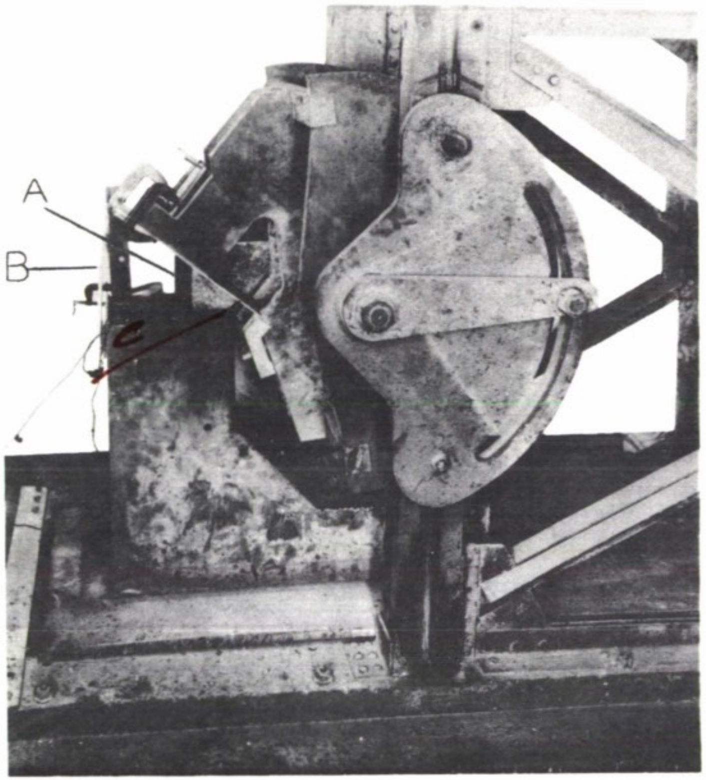


Figure 3. Plate mount with fragment protection box removed

A - Cassette
B - X-ray triggering screen
C - Plate

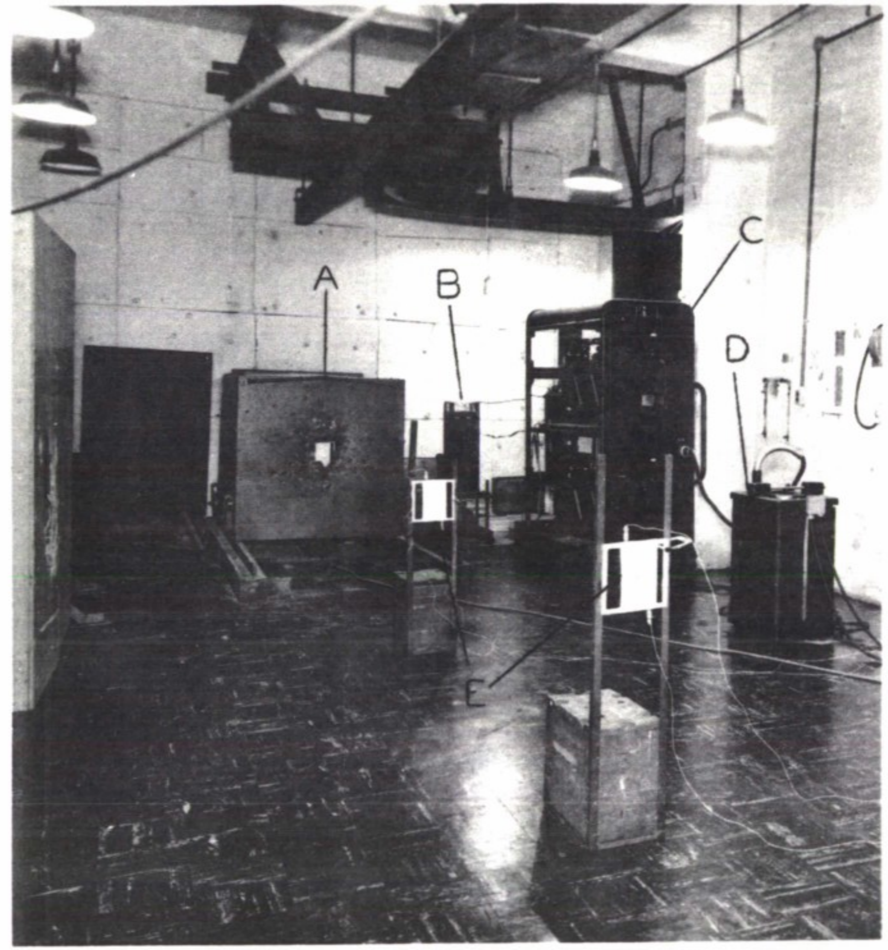


Figure 4. X-ray range setup

A - Fragment protection box
B - X-ray tube (in oil)
C - Surge generator
D - Rectifier unit
E - Velocity screens

Neg. #26240-4
R-1275

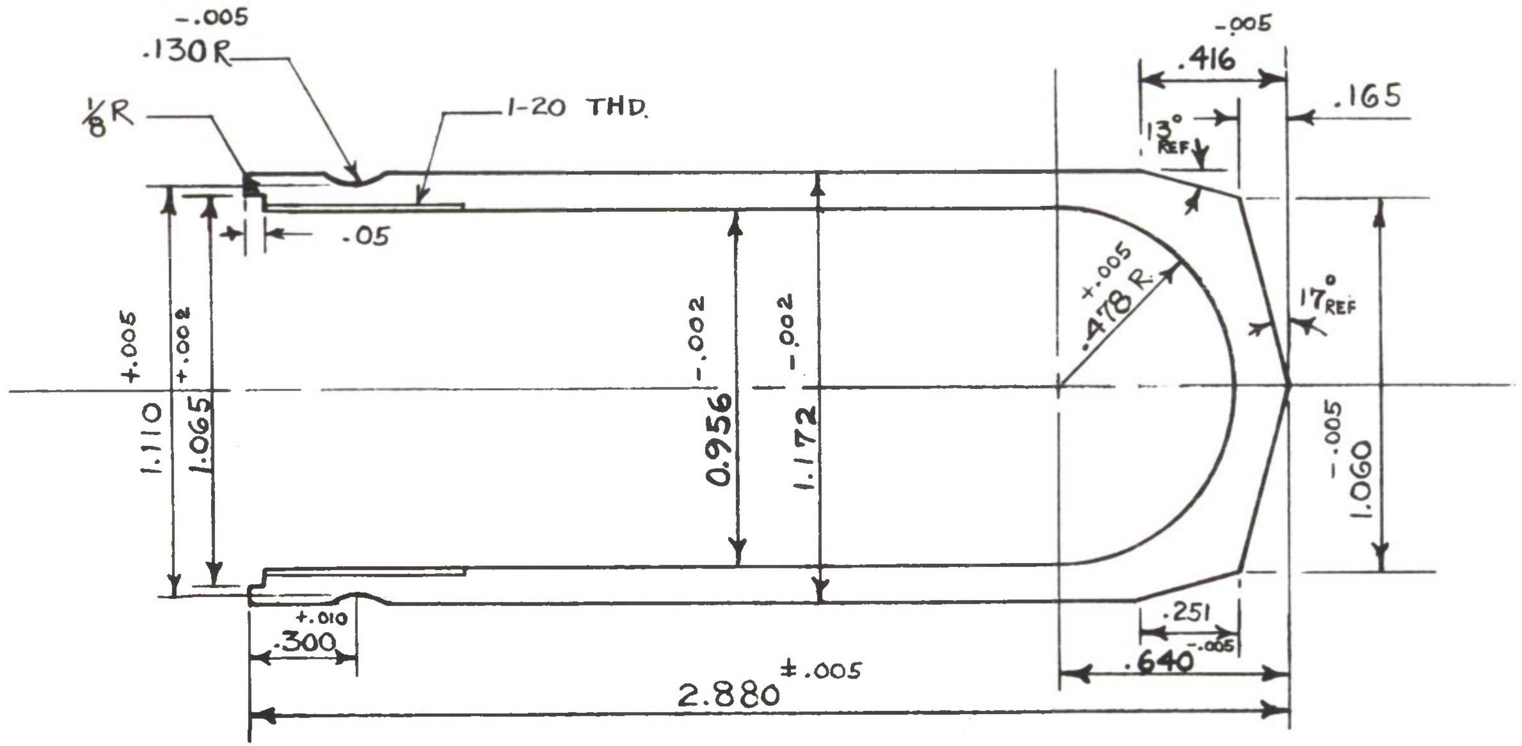


Figure 5. 30 mm HE shell, Model I, prior to application of welded band

a flat nosed cylindrical projectile would remain intact at higher velocities than projectiles with conventional nose shapes. Furthermore, a flat nosed projectile with a tapere biting edge[2] remains intact at even higher striking velocities.

The "flat" portion of the shell was tapered to give more protection at low angles of attack. Under these conditions, the sharper the nose, the higher will be the velocity at which the projectile ruptures.

This model was made from both 1137 and 1045 steels. The 1137 steel was used since it was being used for engineering test lots. The 1045 steel was included since it can be hardened to a higher value than the 1137 steel. Groups of shell made from both steels were tempered at 250°, 400°, 600°, and 800° F to evaluate the effect of hardness on performance.

The shell ~~was~~ were fired against 1/4, 3/8, and 1/2 inch plate at 60° obliquity and against 3/8 inch plate at 0° obliquity at velocities of 2560 to 2700 fps. As may be noted in Table III, the performance of all the shell was poor. X-rays of the two rounds which remained intact, but deformed considerably, are shown in Figure 6. (Some detail has been lost in reproduction of prints from the original X-ray negatives.)

Since the nose portion of the shell was deformed to a great extent in the 60° firing, it was decided to strengthen this section by increasing its thickness.

Table III. Summary of Results for Model I Shell

Target Thickness (in.)	Target Obliquity (deg)	Steel*	Hardness R_c	Striking Velocity (fps)	Condition of Projectile
1/2	60	A	30	2635	Fracture
	60	A	38	2652	"
	60	B	30	2558	"
	60	B	42	2639	"
	0	B	42	2660	"
	0	A	42	2703	"
3/8	60	A	34	2625	"
	0	A	34	2584	"
	0	A	30	2660	"
	0	B	30	2639	Intact, very large swell
1/4	60	A	34	2652	Fracture
	60	A	42	2667	"
	60	B	27	2611	"
	60	B	38	2625	"
	60	B	42	2611	Intact, badly deformed

*A - 1137 steel; B - 1045 steel

2. Ibid

Neg. #26240-5
R-1275

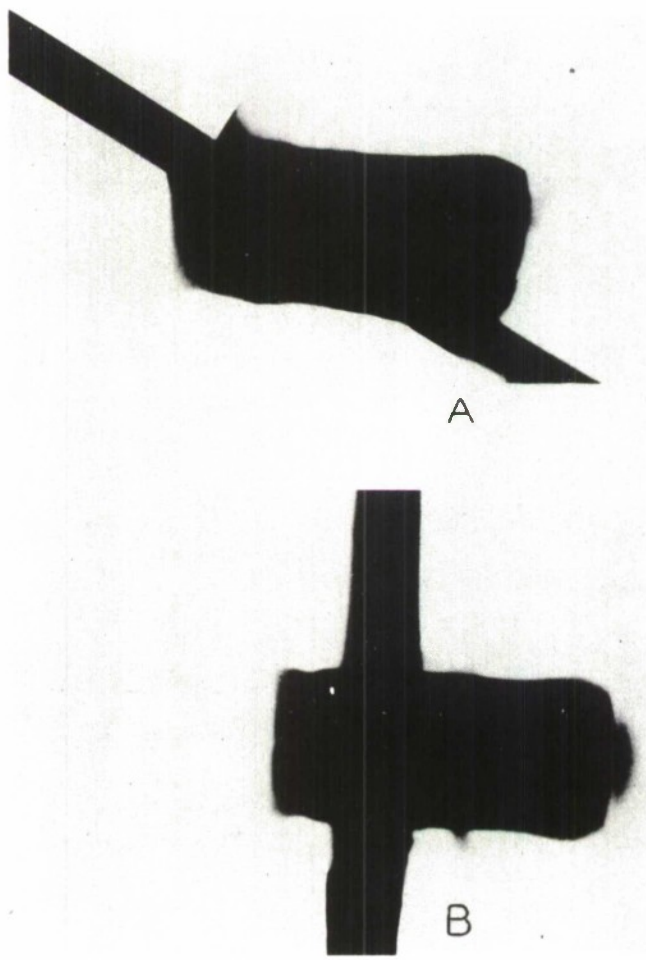


Figure 6. High-speed radiographs of Model IB (R_C 34) intact shell

A - 1/4 inch at 60°, 2611 fps
B - 3/8 inch at 0°, 2639 fps

Models 2 and 3

Sketches of Models 2 and 3 are shown in Figures 7 and 8. Model 2 has the same contour as Model 1, except for the addition of 0.300 inch of steel at the nose of the shell. Model 3 is the same as Model 2, except that the biting edge has not been tapered. It was believed that Model 3 would be more efficient in penetration and that the additional resistance to deformation at the biting edge (which a double conical shape provides) might not be necessary since the target is aluminum. The two models were made from both 1137 and 1045 steels. The 1137 steel was hardened to R_c 42 and the 1045 steel was hardened to R_c 42 and R_c 47.

The target conditions and a summary of the firing results are given in Table IV. All rounds were fired at velocities of 2785 to 2880 fps. The most effective design used in this series was Model 2B (R_c 47) which was the only one capable of remaining intact after defeating 5/8 inch plate at 60° obliquity.

Table IV. Summary of Results for Models 2 and 3
Fired at Velocities of 2785 to 2880 fps

Target Thickness (in.)	Target Obliquity (deg)	No. of Rounds	Model No.	Steel*	Hardness R_c	Condition of Projectile
3/4	45	1	2	A	42	Fracture
	45	1	2	B	47	No picture
	0	1	2	B	47	Fracture
5/8	65	2	2	B	47	1-fracture; 1-intact
	60	2	2	B	47	Intact, large swell
	60	2	2	B	42	Fracture
	60	2	3	B	47	Fracture, large swell

*A - 1137 steel; B - 1045 steel

Neg. #26240-6
R-1275

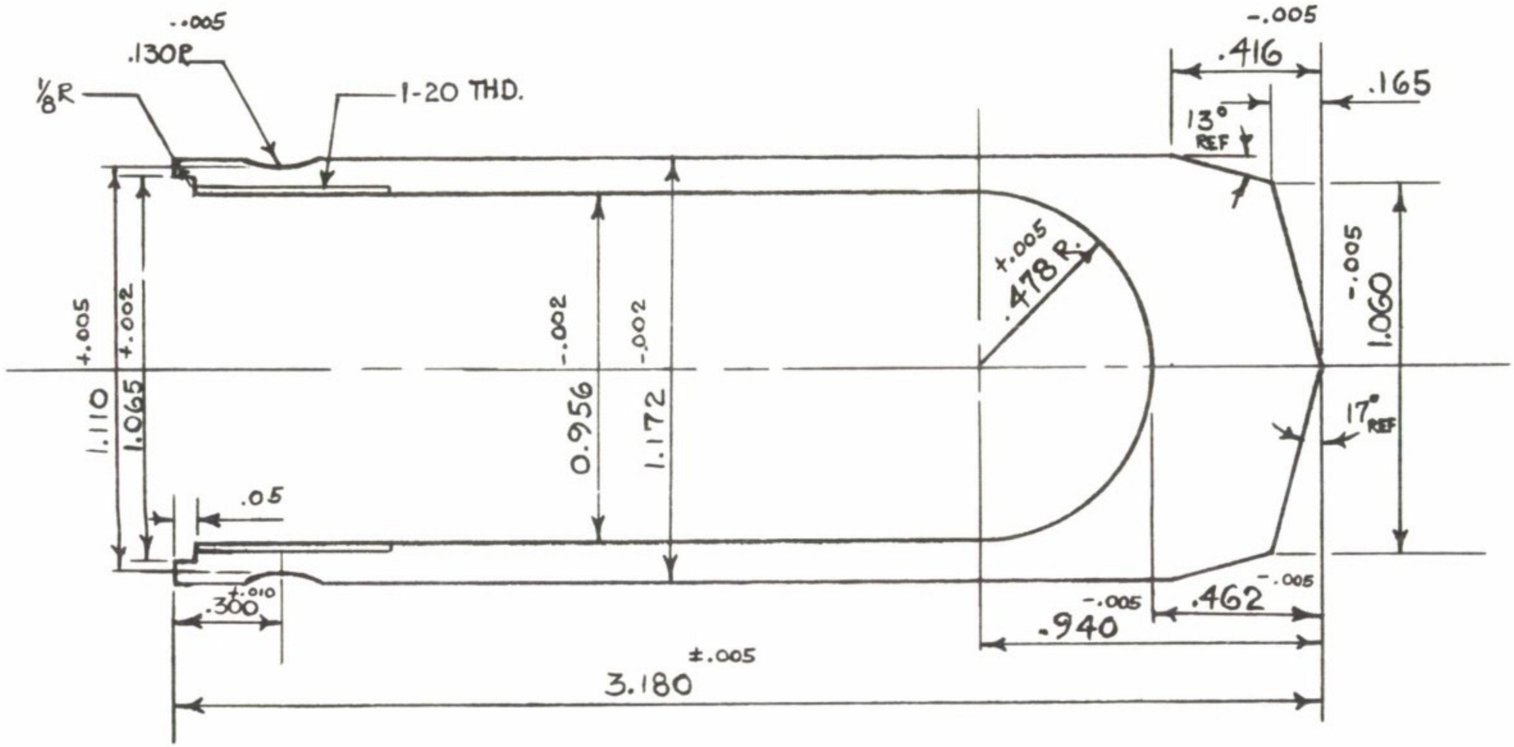


Figure 7. 30 mm HE shell, Model 2, prior to banding

Neg. #26240-7
R-1275

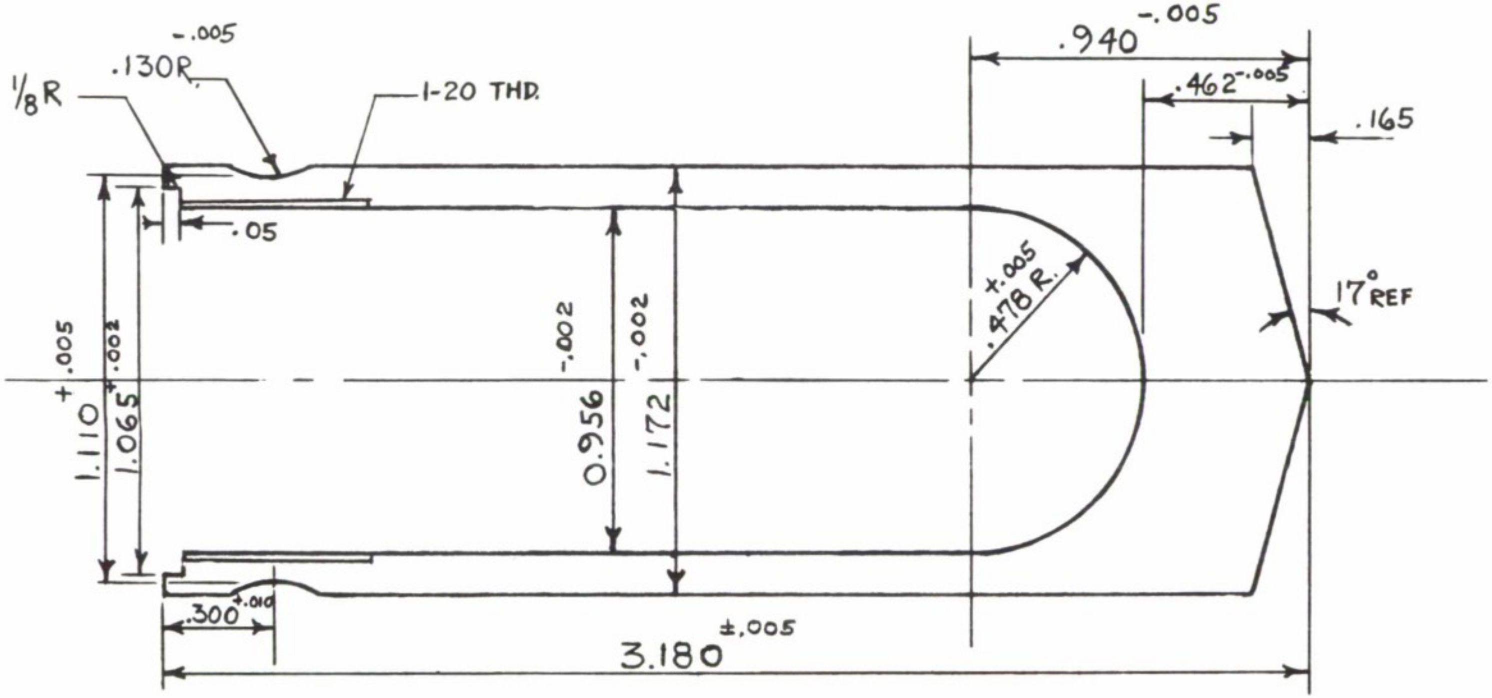


Figure 8. 30 mm HE shell, Model 3

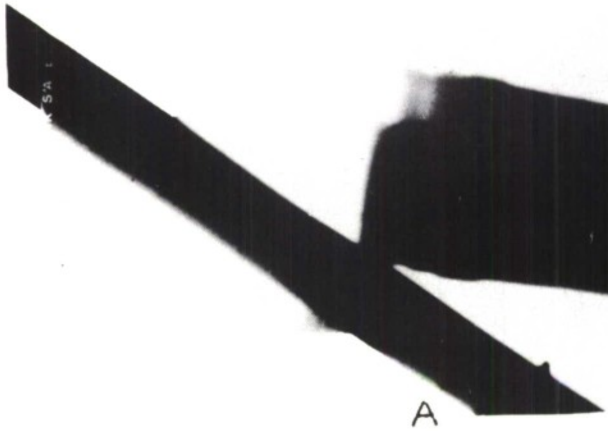
Table IV. Summary of Results for Models 2 and 3
Fired at Velocities of 2785 to 2880 fps (Cont'd)

Target		No. of	Model		Hardness	Condition of
Thickness (in.)	Obliquity (deg)	Rounds	No.	Steel*	R_c	Projectile
1/2	65	3	2	B	47	2 - intact, swell; 1 - fracture
	60	1	2	B	47	Intact, swell
	60	2	2	B	42	Intact, large swell
	60	2	3	B	47	Intact
	60	4	2	A	42	1 - intact, large swell; 3 - fracture, longitudinal split
	60	2	3	A	42	Fracture
	0	2	2	B	47	Intact, swell
	0	1	2	B	42	Ditto
	0	1	3	B	47	Ditto
	0	3	2	A	42	1 - intact, large swell; 2 - longitudinal split
	0	1	3	A	42	Longitudinal split
3/8	70	1	2	B	47	Intact, very slight swell
	70	2	2	A	42	Intact, slight swell
	65	3	2	A	42	Ditto
	60	1	2	B	42	Intact, swell
	60	1	3	B	47	Ditto
	60	2	2	A	42	Intact, no swell
	60	2	3	A	42	1 - intact, large swell; 1 - fracture
	0	1	3	A	42	Fracture

*A - 1137 steel; B - 1045 steel

High-speed radiographs of typical failures of shell made of the different steels are given in Figure 9. The shell of 1137 steel usually split longitudinally with the crack extending to the point of the shell (Figure 9A) while the shell made of 1045 steel cracked at right angles to the axis where the inside radius becomes tangent to the inside diameter. Longitudinal cracking may be due to longitudinal sulphur stringers

Neg. #26240-8
R-1275



A

B

C

Figure 9. High-speed radiographs of typical failures of Model 2 and 3 fractured shell

A - Model 2A (R_C 42), 1/2 inch at 60°, 2841 fps
B - Model 2B (R_C 42), 5/8 inch at 60°. 2801 fps
C - Model 3B (R_C 47), 5/8 inch at 60°. 2833 fps

which sometimes are present in 1137 steel. These stringers are zones of weakness and provide paths for crack propagation. Because of these stringers, this steel is no longer considered acceptable for HE shell.

Model 3B shell did not fail in the nose section, but failed in the same manner as did Model 2B (Figure 9C); therefore, the inferiority of these shell is not due to the weakness of the biting edge. For Model 3B there is a larger area that is loaded in the beginning of penetration, and this transmits a larger force to the body.

While Model 2B was quite effective, a study of Figures 9B and 10 indicates further possible improvements. The shell failed at the region of maximum swell, which is just rearward of the point of tangency of the inner radius. Therefore, Model 4 was designed to give greater wall thickness in the region where Model 2 failed.

Model 4

A sketch of Model 4 is given in Figure 11. The outside contour of this shell is the same as that of Model 2, while the inside contour is similar to a conventional ogive.

All shell of Model 4 were made from 1045 steel. Groups of the shell were tempered to R_c hardnesses of 56, 51, 46, and 40. A summary of the firing is given in Table V.

This design (Model 4) could remain intact in defeating 3/4 inch plate between 45° and 70° obliquities (30° and 75° obliquities were not investigated), and 5/8 inch plate from 30° to 75° obliquities. Only the softest shell could defeat 5/8 inch plate at 0° obliquity without fracturing; the hardest ones could not defeat 1/2 inch plate at 0° without fracturing. None of the shell could perforate 1/2 inch plate at 80° obliquity.

Sample X-ray photographs of the 3/4 inch plate firings are given in Figures 12 and 13, and of the 5/8 inch plate firings in Figures 14, 15, and 16. For both targets, the deformation of the shell decreased with increasing obliquity. At low obliquity, the softer shell deformed more; however, due to their greater ductility, they were able to undergo more extensive deformation without rupturing. The rounds at 75° obliquity were turned considerably (approximately parallel to the plate) after perforating the target.

X-ray photographs of the 1/2 inch plate firing are given in Figure 17. As against 5/8 inch plate, the softer shot were better at normal obliquity. At 80° obliquity, the shell punched a large hole through the plate, but ricocheted intact. At the moment the X-ray was taken, the base of the shell was through the plate.

Neg. #26240-9
R-1275

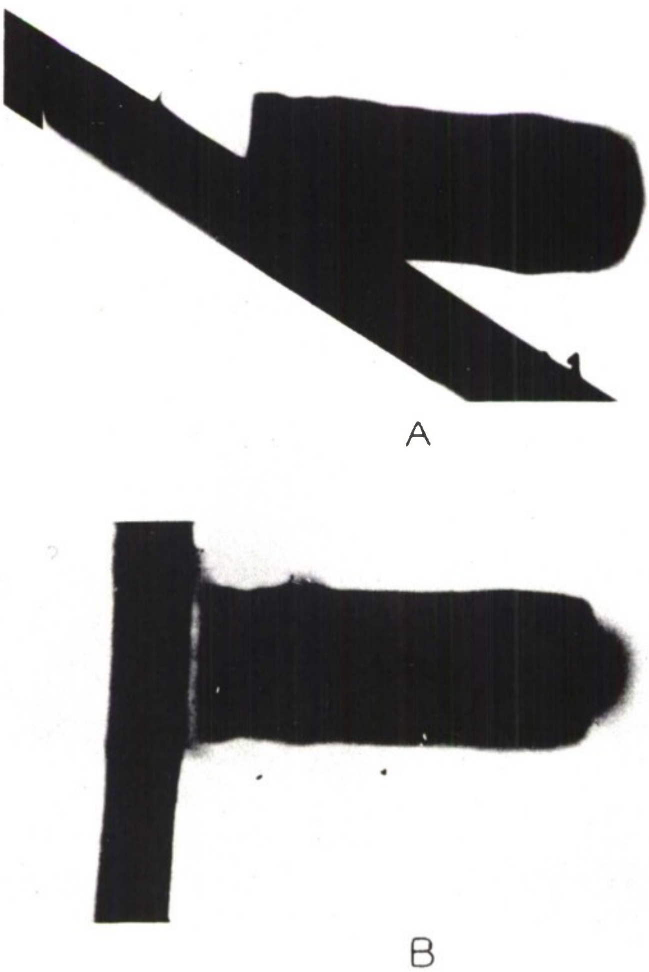


Figure 10. High-speed radiographs of Model 2B intact shell

A - R_C 47 vs 5/8 inch at 60°, 2800 fps
B - R_C 42 vs 1/2 inch at 0°, 2833 fps

[redacted]

Neg. #26240-10
R-1275

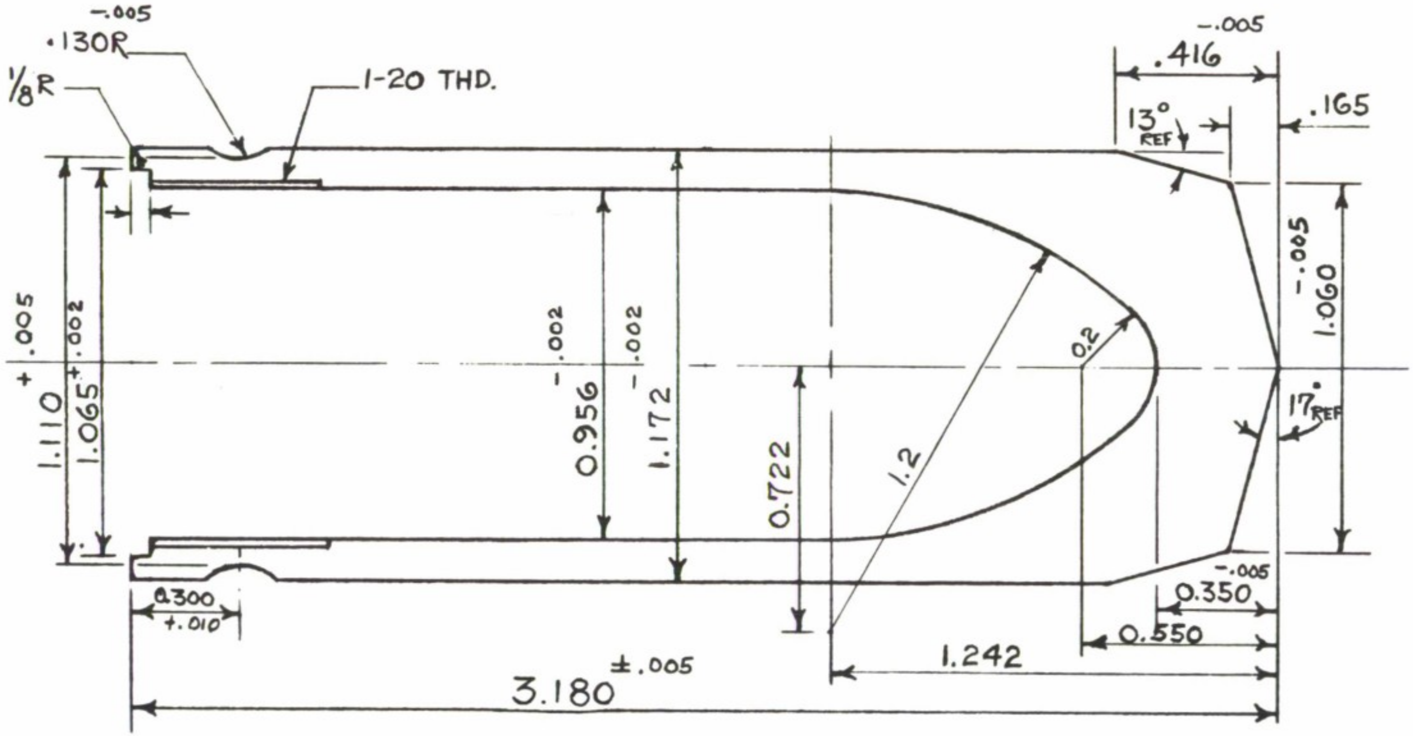
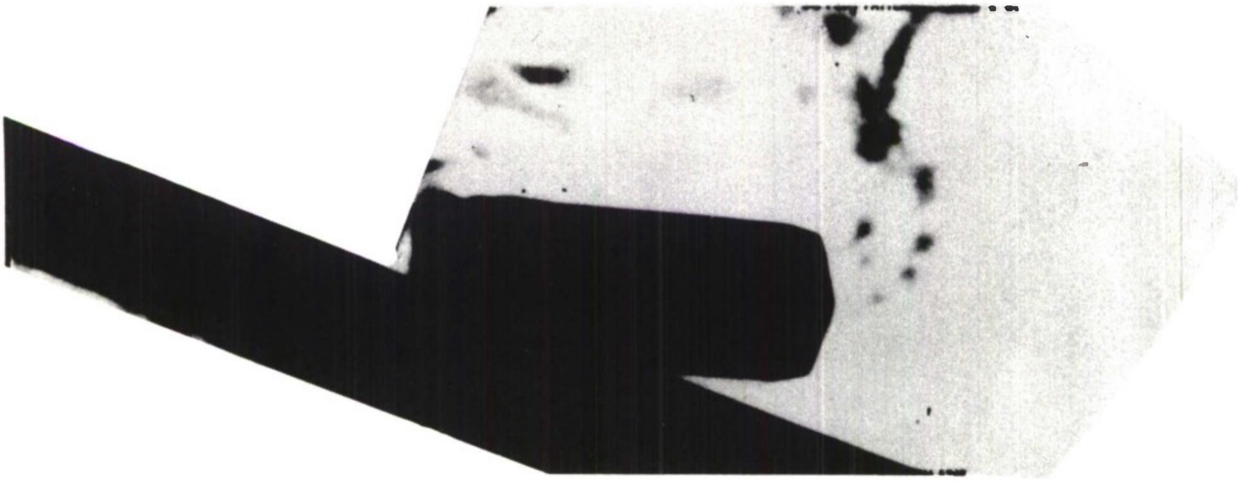


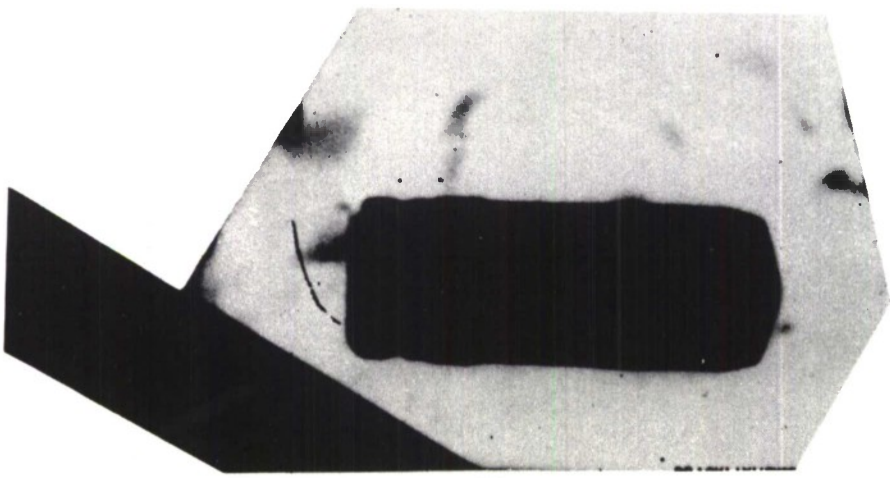
Figure 11. 30 mm HE shell, Model 4

[redacted]

Neg. #26240-11
R-1275



A

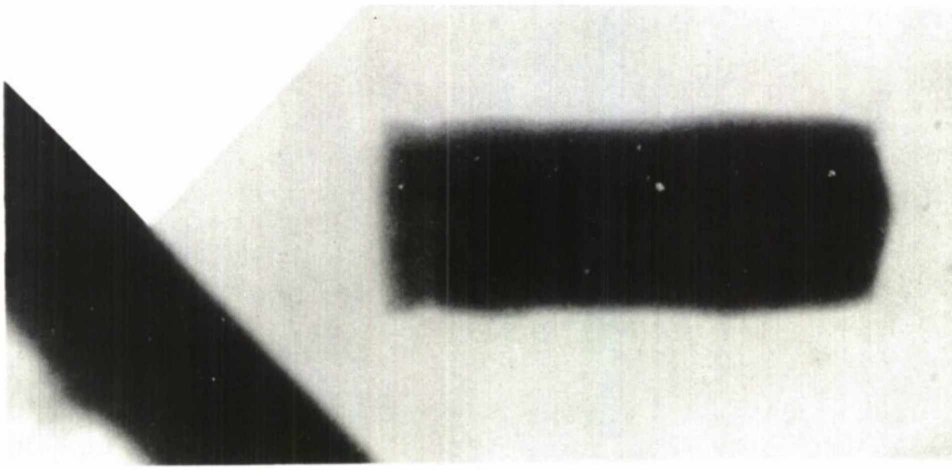


B

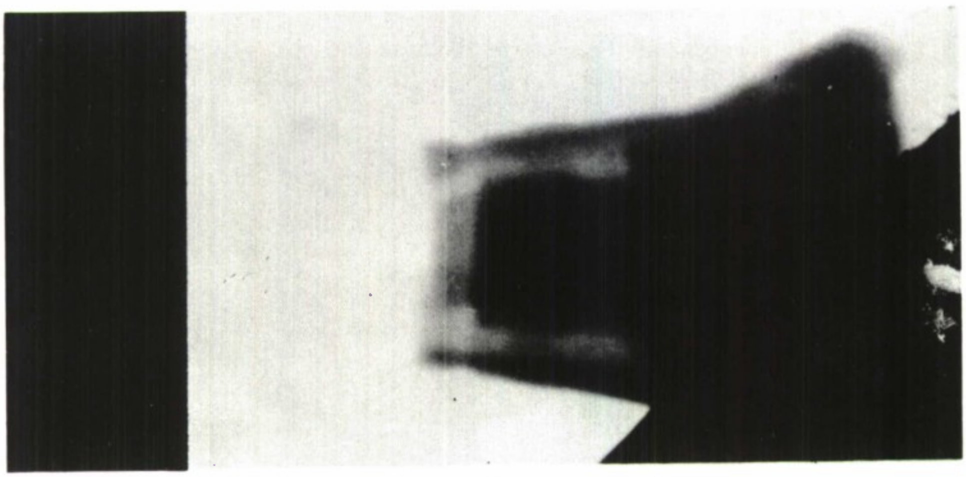
Figure 12. High-speed radiographs of Model 4 (R_C 56) intact shell vs 3/4 inch plate

A - At 70°, 2907 fps
B - At 60°, 2899 fps

Neg. #26240-12
R-1275



A



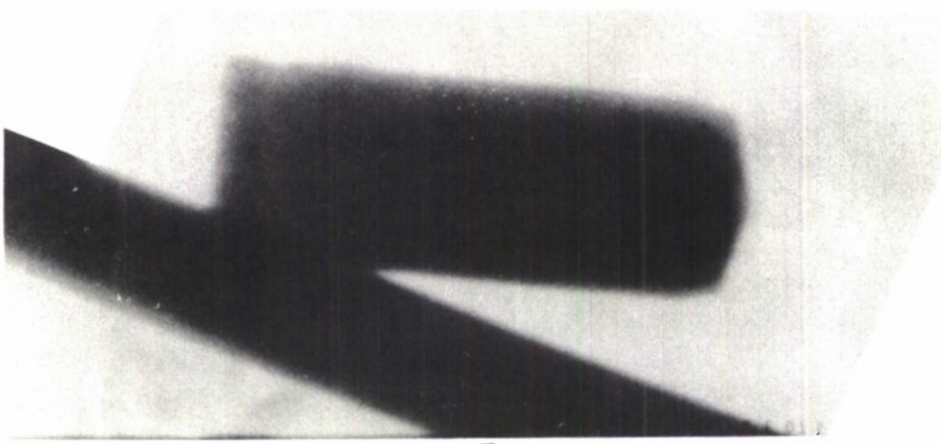
B

Figure 13. High-speed radiographs of Model 4 (R_C 46) shell vs 3/4 inch plate

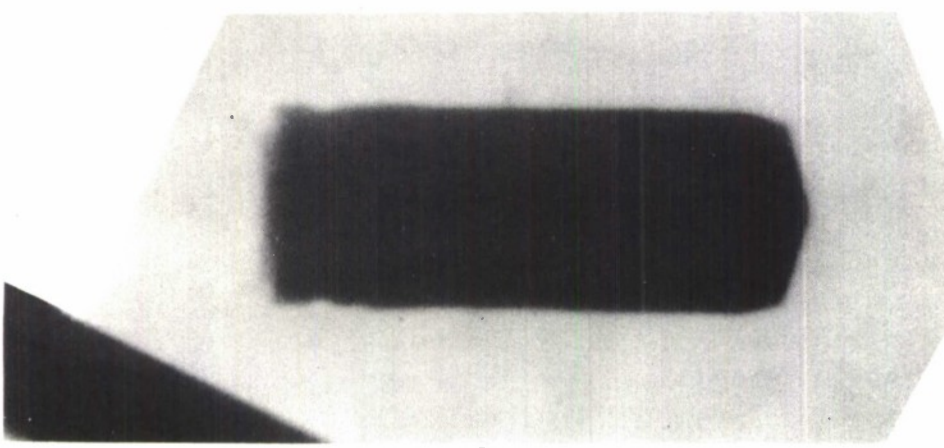
A - Intact, at 45°, 2907 fps
B - Fracture, at 0°, 2937 fps

Neg. #25240-13
R-1275

A



B

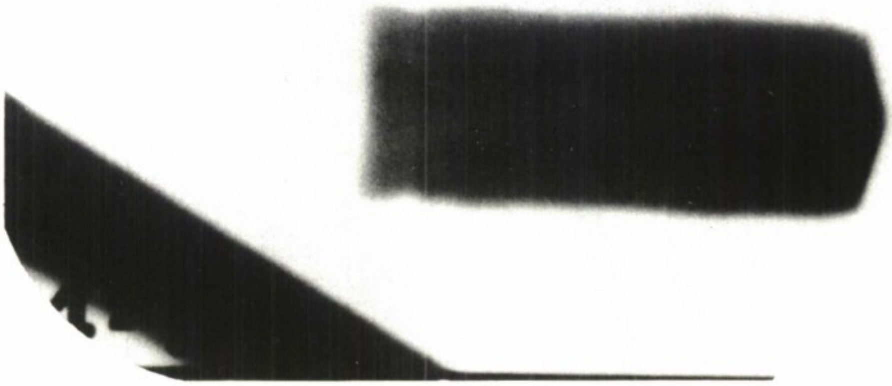


C

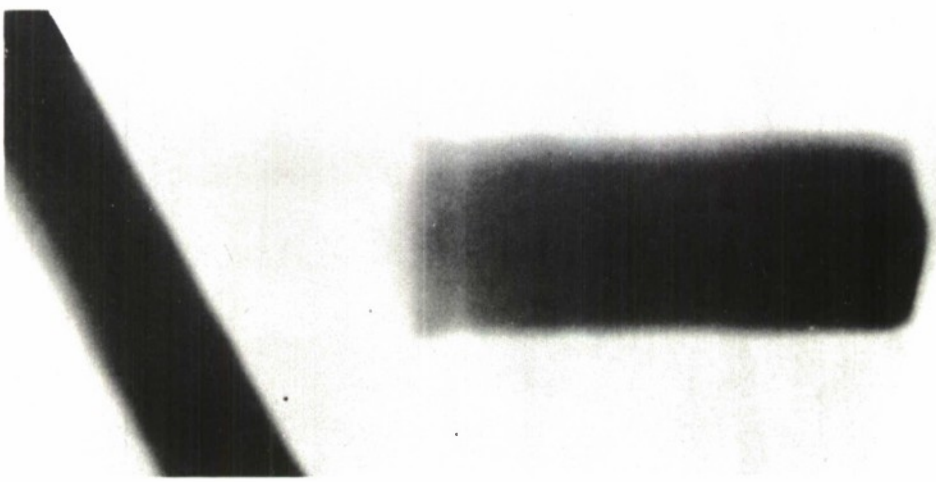
Figure 14. High-speed radiographs of Model 4 intact shell vs 5/8 inch plate

A - Model 4 (R_C 56), at 75°, 2899 fps
B - Model 4 (R_C 46), at 70°, 2933 fps
C - Model 4 (R_C 56), at 65°, 2950 fps

Neg. #26240-14
R-1275



A

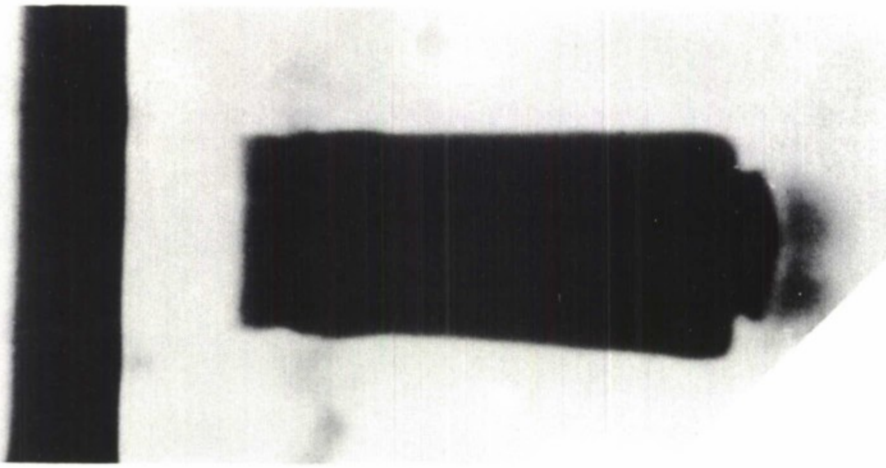


B

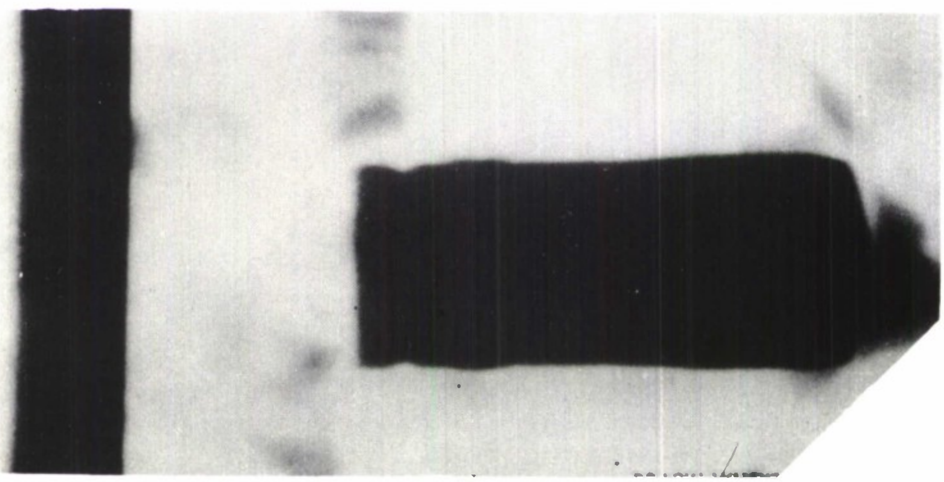
Figure 15. High-speed radiographs of Model 4 (R_C 46) intact shell vs 5/8 inch plate

A - At 60°, 2890 fps
B - At 30°, 2890 fps

Neg. #26240-15
R-1275



A

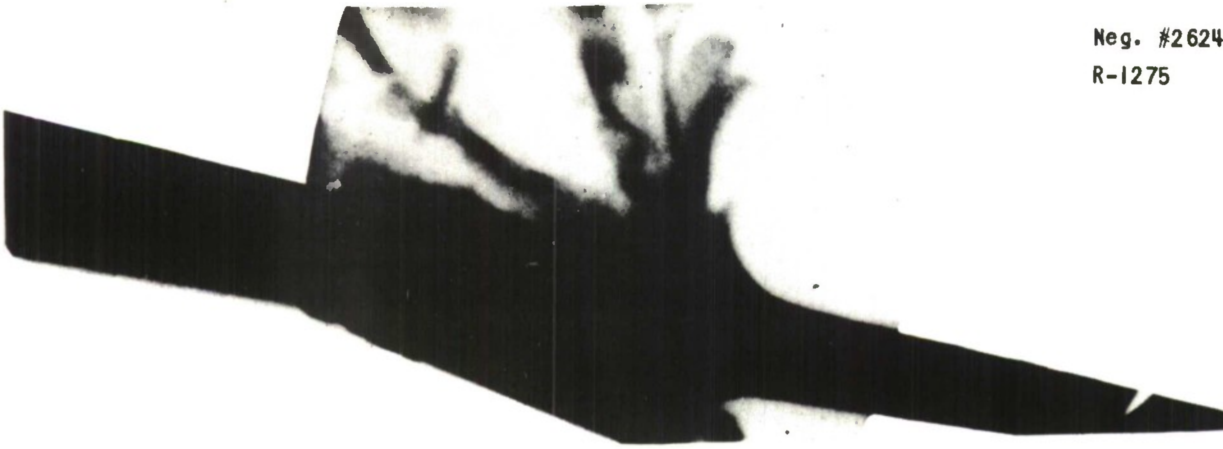


B

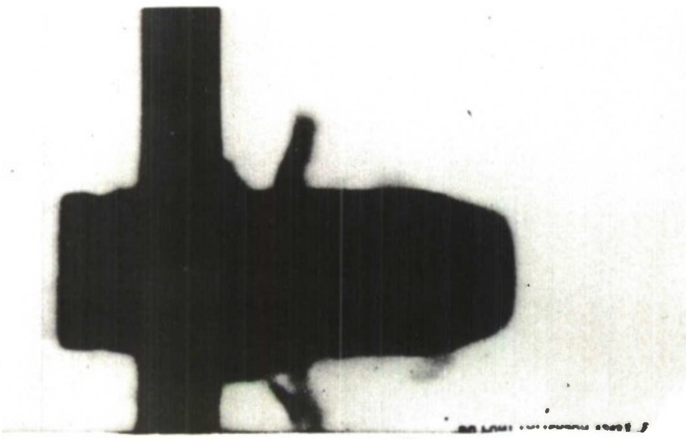
Figure 16. High-speed radiographs of Model 4 shell vs 5/8 inch plate at 0°

A - Model 4 (R_C 56), fracture started, 2907 fps
B - Model 4 (R_C 40), intact, 2857 fps

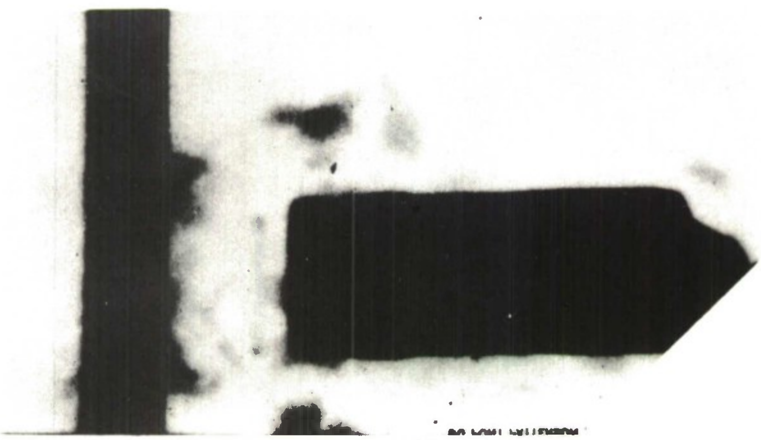
Neg. #26240-16
R-1275



A



B



C

Figure 17. High-speed radiographs of Model 4 shell vs 1/2 inch plate

A - Model 4 (R_C 46), intact; incomplete penetration at 2890 fps, 80°
B - Model 4 (R_C 56), fracture started at 2899 fps, 0°
C - Model 4 (R_C 56), intact at 2899 fps, 0°

Table V. Summary of Results for Model 4

Target					
Thickness (in.)	Obliquity (deg)	Rounds Fired	Striking Velocity (fps)	Hardness R_c	Condition of Projectiles
3/4	70	1	2907	56	Intact, no swell
	70	1	2915	51	Intact, very slight swell
	70	1	2841	46	Intact, slight swell
	70	1	2865	40	Intact, slight swell
	60	1	2899	56	Intact, no swell
	60	1	2882	51	Intact, slight swell
	60	1	2907	46	Intact, very slight swell
	60	1	2907	40	Intact, swell
	45	1	2899	56	Intact
	45	1	2924	51	Intact, swell
	45	1	2907	46	Intact, swell
	45	1	2865	40	Intact, swell
	0	1	2941	56	Fracture
	0	2	2937	46	Fracture
5/8	80	1	2882	56	Intact, incomplete perforation
	75	1	2899	56	Intact, no swell
	75	1	2907	51	Intact, no swell
	75	1	2915	40	Intact, no swell
	70	2	2907, 2941	56	Intact, no swell
	70	2	2933, 2941	46	Intact, slight swell
	65	4	2833, 2840,* 2940,* 2941	56	Intact, no swell
	65	4	2841, 2841, 2933, 2941	46	Intact, slight swell
	60	2	2841, 2833	56	1 - intact, swell; 1 - intact, no swell
	60	2	2865, 2890	46	Intact, slight swell
	30	1	2915	56	Intact, slight swell
	30	1	2907	51	Intact, swell
	30	1	2890	46	Intact, swell
	30	1	2907	40	Intact, swell
	0	2	2907, 2915	56	Fracture started
	0	1	2899	51	Fracture started
	0	2	2899, 2915	46	Split in half
	0	1	2857	40	Intact, swell
1/2	80	1	2890	46	Intact, incomplete perforation
	75	1	2870	46	Intact
	0	2	2899	56	Fracture
	0	2	2899, 2882	46	Intact, slight swell

*Estimated

This shell design is exceptionally good for all obliquities between 30 and 75 degrees. To improve its performance at 0° obliquity, the flat end could be made smaller, and lower hardnesses could be tried to find the optimum hardness. To improve its performance at the very highest obliquity, the forward portion should be made to approach a cylinder more closely. However, a modification of this type might make the shell behave like Model 3.

CONCLUSIONS

1. A solid nose, base fuzed 30 mm shell has been designed which is at least twice as effective for penetration as the present nose fuzed design (T306E10) against 60° and 70° obliquity aluminum armor targets. The shell practically satisfies the original penetration requirements.

2. It is possible for the shell to remain intact after defeating 3/4 inch 24S-T4 aluminum alloy plate between 45° and 70° obliquities and 5/8 inch plate from 0° to 75° obliquities at velocities of 2800 to 3000 fps.

FUTURE WORK

While this inert loaded shell practically satisfies the original penetration requirements, it does not conform to the exterior contours required for the gun. A modification of this shell, which approaches these requirements, has been made. Shell of this design will be tested against various target conditions, and flash radiographs will be taken of them after penetration to observe their performance and to find ways of improvement, under the restrictions of exterior contour, explosive capacity, and total weight.

RECOMMENDATIONS

It is recommended that the blunt nosed principle of design be considered for other types of HE and small arms armor piercing ammunition.

Distribution

1 - Chief of Ordnance
Department Army
Washington 25, D. C.
Attn: ORDTX-AR

2 - Attn: ORDTS

1 - Attn: ORDIM

1 - Attn: ORDTB

1 - Commanding Officer
Springfield Armory
Springfield 1, Mass.
Attn: Eng Dept

1 - Commanding General
Picatinny Arsenal
Dover, New Jersey
Attn: Tech Group

1 - Commanding Officer
Rock Island Arsenal
Rock Island, Ill.
Attn: Laboratory

1 - Commanding Officer
Watertown Arsenal
Watertown 72, Mass.
Attn: Tech Group

1 - Director
Ordnance Materials
Research Office
Watertown Arsenal
Watertown 72, Mass.

1 - Commanding Officer
Lake City Arsenal
Independence, Missouri
Attn: H. W. Kline

1 - Commanding Officer
Diamond Ordnance Fuze
Laboratories
Washington, D. C.

1 - Parke-Thompson Associates
501 South Holmes
Kirkwood 22, Missouri
Attn: Div of Atlas Powder Co.

1 - Commanding Officer
Kingsbury Ordnance Plant
Laporte, Indiana
Attn: O. C. Shannon

1 - Commanding General
Ordnance Ammunition Center
Joliet, Illinois
Attn: E. T. Hackett

1 - Commanding General
Aberdeen Proving Ground
Maryland
Attn: Lab Serv Div

1 - Attn: Ball Res Lab

1 - Attn: Tech Info Br, Bldg 313

2 - Attn: D & PS - Term Ball Lab

1 - Commandant
U. S. Naval Proving Ground
Dahlgren, Va.
Attn: Term Ball Dept

5 - Armed Services Technical
Information Agency
Document Service Center
Knott Building
Dayton 2, Ohio
Attn: DSC-SD
(Code 1)

1 - Dr. C. W. Curtis
Dept of Physics
Lehigh University
Bethlehem, Pa.

1 - Bulova Research and
Development Laboratories, Inc.
62-10 Woodside Avenue
Woodside, New York
Attn: O. B. Brockmeyer

1 - Hesse Eastern Corp.
Cambridge 38, Mass.
Attn: S. C. Hutchinson